AIR FORCE RESEARCH LABORATORY [AFRL]

Manager of the Basic Research Investment for the Air Force Research Laboratory

Research

JUL AUG 99

New Paint Compounds Provide Early Detection of Corrosion to Aircraft

Scientists now have a new method for attacking a chronic, billion dollar problem associated with aircraft – corrosion. Researchers supported by AFOSR discovered a paint compound that changes color when corrosion is present, allowing for earlier and less costly maintenance.

Drs. Gerald S. Frankel and Jian Zhang, from Ohio State University, supported by AFOSR and AFRL Materials Directorate, developed a paint that detects changes in acidity and alkalinity, measured as pH. The coatings they developed, incorporating phenolphathalein into the compound, change from colorless to red above a given pH.

This new corrosion technology will provide maintenance crews with an improved capability to identify and repair corroded metal. This discovery has the potential to replace the labor-intensive process of using expensive non-destructive evaluation processes to identify corrosion.

This new method will be especially useful for detecting the most troublesome corrosion, which is concealed around rivets and in the joints where sheets of metal overlap. By using this compound, maintenance crews will know corrosion is present in a joint or rivet when the surrounding area changes to a reddish color.

Conversely, the absence of any color changes will also signal that there is no corrosion present.

The researchers are also attacking corrosion on another front. Corrosion becomes apparent when using an acrylic mixed with a compound that fluoresces under ultraviolet light when above a certain pH. By measuring the emitted light with a spectrophotometer, the researchers may be able to quantify the color change and the extent of corrosion.

More information is available at this website: **http://mse-gsf1.eng.ohio-state.edu/fcc/papers/Sensing_Paint/CorroSensingCoating.htm**

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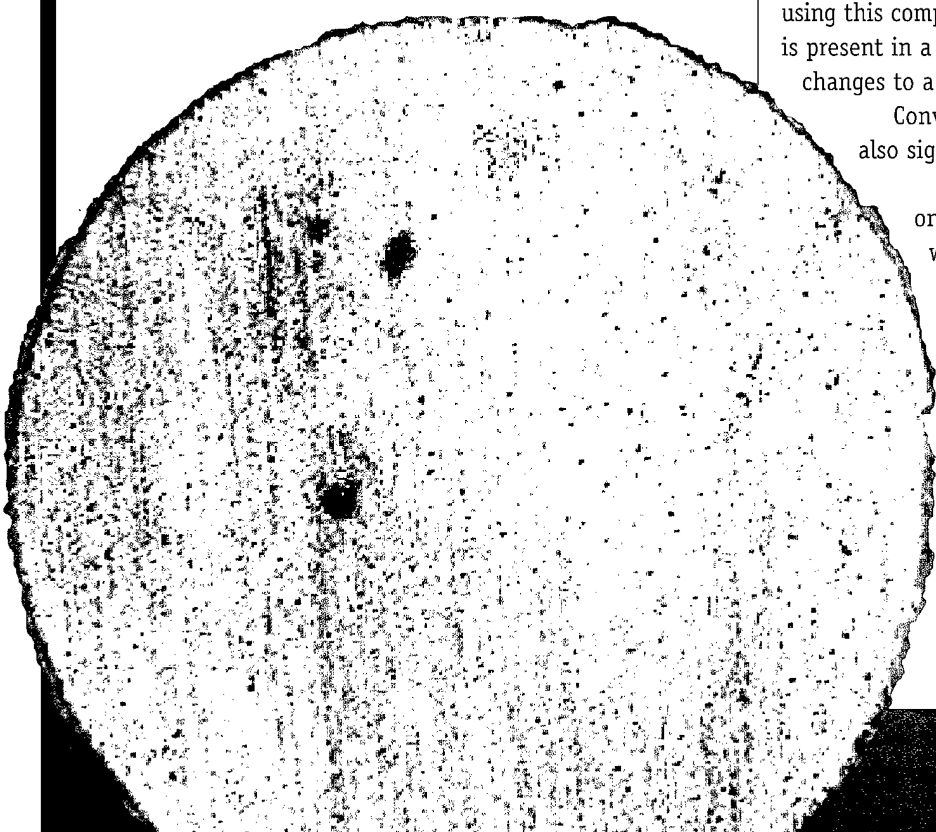


Sample coated with acrylic+phenophthalein (critical pH=10) following exposure to 1 M NaCl for eight days.

Holographs Correct Images from Space

By Capt. Matt Forsbacka

An inexpensive method to correct images obtained from high-priced optical instruments used in space surveillance has the potential to save the Air Force money and improve space operations.

AFOSR-sponsored research at the USAF Academy's Laser and Optics Research Center is demonstrating how holograms can facilitate low cost, high precision optical instruments. Defects such as aberrations in optical elements can be corrected using low cost holograms to produce near-perfect space images. Applications include:

- Space surveillance using a telescope that could monitor the Earth from a geostationary platform over a continuous 24-hr. period down to a resolution of 200mm, or eight inches. A small, inexpensive hologram would enable the use of low-quality inflatable or unfurlable membrane mirrors for the primary mirror. Such an approach would greatly reduce the launch and fabrication costs (and hence the risk) while making possible construction of telescopes with extremely high resolution.
- Enhancements to micromachining and photolithography techniques result in high resolution, real time microscopic imaging even while maintaining a large working distance. Using an inexpensive high numerical aperture Fresnel lens objective, a low-cost hologram corrects aberrations enabling working distances an order of magnitude greater than that achievable by conventional optics.

HOW IT WORKS

The process requires recording a demagnified image hologram of the low-quality primary optic (mirror or lens) using laser light. The hologram is a perfect record of the position and magnitude of all the imperfections on the optic.

The hologram is a small medium, usually about an inch in diameter, and can be produced on film at a cost of less than $1. When focused light from the primary lens or mirror is passed through the hologram, the wavefront aberrations are removed and an aberration-free beam is produced. Thus, a large, inexpensive primary mirror can be used to collect large amounts of light at high resolution, with a small hologram used for image correction.

FOCUS ON THE FUTURE

In addition to surveillance, another potential application for holographically-corrected telescopes would be to provide the foundation for an inexpensive network of high-bandwidth optical communications satellites. Academy researchers have

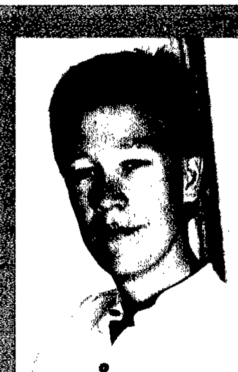
Effects of Using Holographically Corrected Telescopes

Aberrated Focus

Corrected Focus

The aberrated focus (left) shows a photo taken before correction. The photo on the right shows the same image, 10,000 times smaller, using a holographically corrected telescope.

Profile of Dr. Geoff Andersen



Dr. Geoff Andersen

RIGHT: Dr. Geoff Andersen was born in Tasmania, Australia and by the age of 25 had earned his bachelor's, master's and PhD in Physics from The University of Adelaide. After serving as a postdoctorate researcher at the University of Adelaide, he accepted a Research Fellowship at the U.S. Air Force Academy in 1996. At the Air Force Academy, he is specializing in holography, optical instrumentation and lidar. He is currently designing and building a Raman lidar system to measure temperature profiles of the lower atmosphere. He has published six papers and has four patents pending.

demonstrated that these telescopes can handle data rates of up to 100 Gbits/second or 2 million times faster than a high-end (56K) PC modem. Such inexpensive telescopes are ideal for future networks requiring large numbers of easily constructed, low-risk modules that can provide greater information collection and exchange in the command, control, and communications (C^3) environment.

Finally, the telescopes may also be used for directed energy beam propagation. While the airborne laser (ABL) is now under construction for theater-wide defense, the challenge of global-reach capability is still under development. One possibility would be to use large aperture bounce mirrors to project high-powered laser beams from a CONUS ground station to specific region anywhere on Earth. Since large aperture mirrors would be required for such an application, holographically corrected telescopes might provide a valuable conduit.

More information is available at: **www.usafa.af.mil/dfp/research/lorc/tele.htm**

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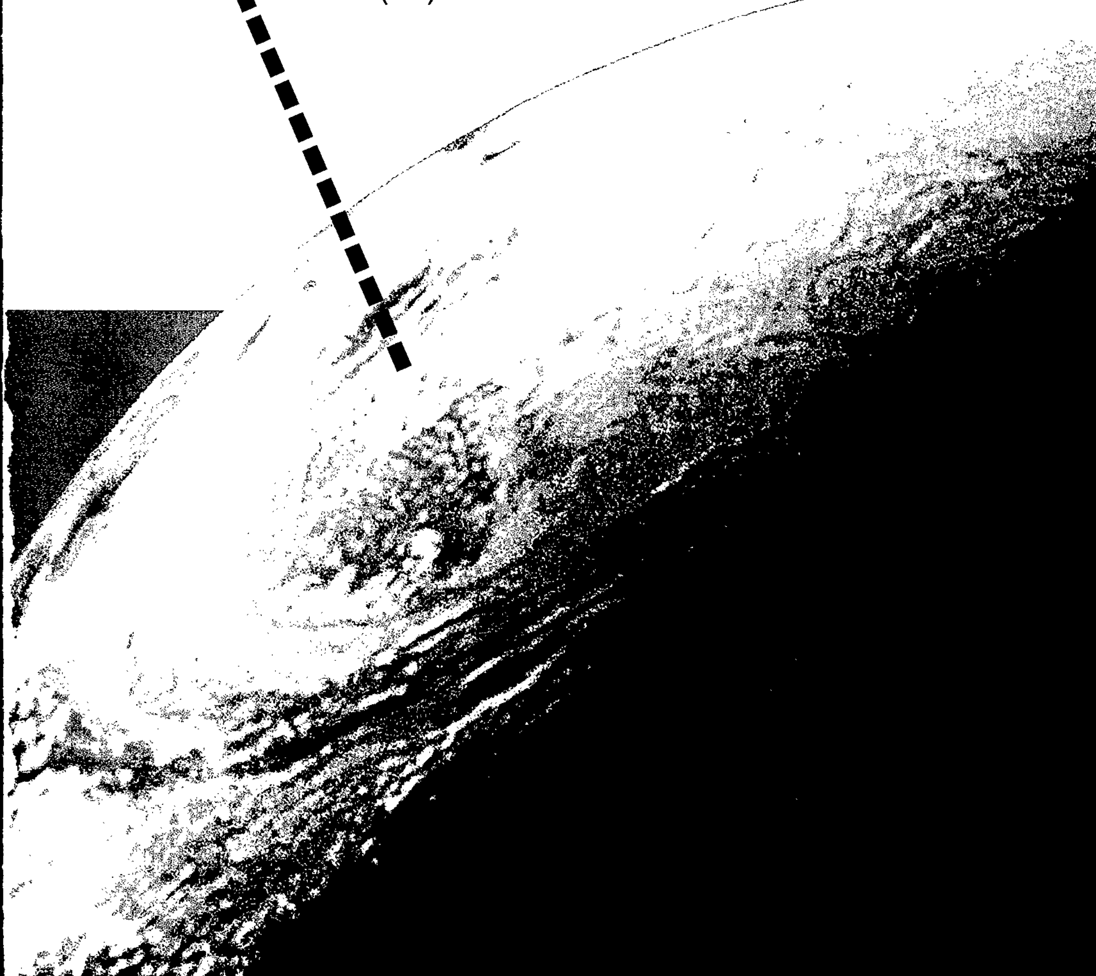

Asian Office on the Move

The Asian Office of Aerospace Research and Development (AOARD) was established in 1992 by the Air Force Office of Scientific Research (AFOSR). AOARD supports the research and development community by identifying foreign science and technology capabilities and accomplishments and by facilitating technical interactions between the Air Force Research Laboratory and their counterparts within Asia and the Pacific Rim. AOARD serves as a liaison with members of the scientific and engineering community and encourages open communication between Air Force scientists and engineers and their counterparts within their areas of responsibility. The office also monitors important research, development, and manufacturing technology of direct and potential usefulness to the Air Force.

AOARD recently moved into a renovated facility in the Pacific Stars and Stripes building. Their address, phone number and Internet address are:

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Dr. Irvin Glassman Honored for Contributions to Air Force Research

With contributions spanning from the Sputnik era into the future with the Joint Strike Fighter and hypersonic flight vehicles, a Princeton researcher has helped provide propulsion to the Air Force's space and aircraft programs. This researcher has received continuous support for his research from AFOSR for more than 45 years.

Dr. Irvin Glassman, the Robert H. Goddard Professor of Mechanical and Aerospace Engineering at Princeton, has used his expertise in combustion to aid the Air Force in developing rockets and jet aircraft. His research efforts will be reflected in the development of the F-22, Joint Strike Fighter and hypersonic flight vehicles.

Glassman's contributions to the Air Force started in the 1950's just as America was entering the Space Age. His research led to the development of the Glassman Criterion for vapor-phase combustion. This criterion established that aluminum would burn efficiently in solid propellants while boron would not despite its higher energy density. This finding led to the use of aluminum as a component in solid propellant rockets.


Dr. Irvin Glassman

His research in the 1960's resolved combustion instability problems in the Agena rocket, which served as an upper stage in the Thor-Agena, Atlas-Agena and Titan 3-Agena space launch systems. The Agena, which was used from 1959 to 1987, was America's most used top stage with 362 launches.

Glassman also used his expertise to resolve complex issues with jet engines. In the 1970's, he contributed to the development of the Emdee-Brezinsky-Glassman model. This model is used to predict fuel oxidation for JP-type fuels in Air Force gas turbine engines and provides the basis for estimating the production of soot and detectable exhaust signature in aircraft. This modeling allows the engine designer to extend engine lifetime, reduce maintenance requirements, minimize detectable combustion signature, and comply with regulations to protect the environment from harmful exhaust particulate emissions.

Following this research, Glassman's efforts in the 1980's clarified the role of temperature as a controlling parameter to establish the relative sooting tendency of different jet fuel components.

In this decade and the next, as the Air Force develops the Joint Strike Fighter, the F-22 and hypersonic flight vehicles, Glassman's research will also be used. His integrated approach for understanding the fouling tendencies of hydrocarbon fuels at high temperature and pressure is key in developing systems, like the Joint Strike Fighter, F-22 and hypersonic flight vehicles, that require fuel to absorb heat from the vehicle skin, propulsion system and other components.

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Research Highlights

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Research Highlights is published every two months by the Air Force Office of Scientific Research. This newsletter provides brief descriptions of AFOSR basic research activities including topics such as research accomplishments, examples of technology transitions and technology transfer, notable peer recognition awards and honors, and other research program achievements. The purpose is to provide Air Force, DoD, government, industry and university communities with brief accounts to illustrate AFOSR support of the Air Force mission. *Research Highlights* is available on-line at:

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